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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

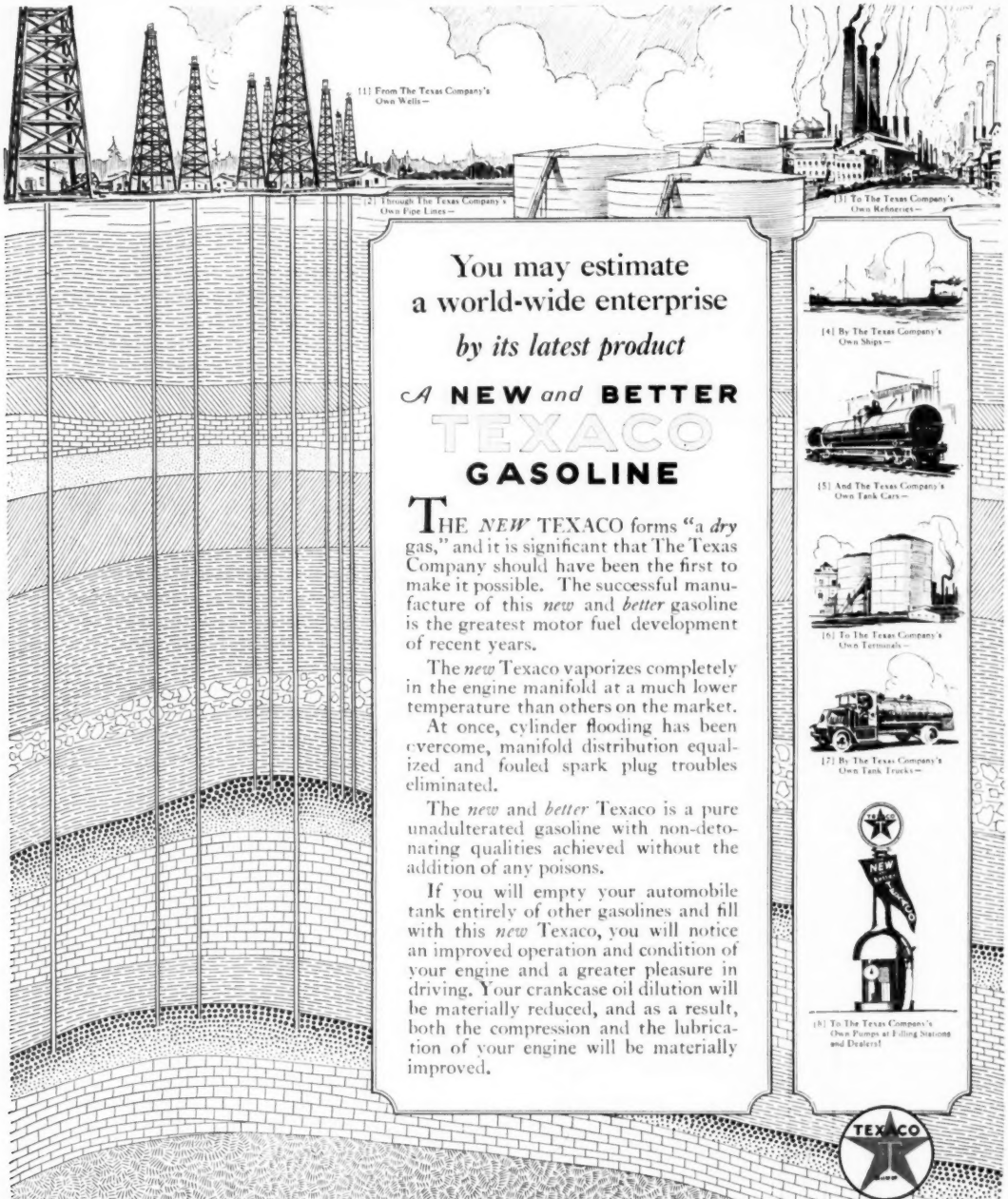
THIS ISSUE

Lubrication Protection

Oil Filtration and Purification

Filtering and Cleaning of Air

PUBLISHED MONTHLY BY
THE TEXAS COMPANY, U.S.A.
TEXACO PETROLEUM PRODUCTS


[1] From The Texas Company's Own Wells—
[2] Through The Texas Company's Own Pipe Lines—
[3] To The Texas Company's Own Refineries—
[4] By The Texas Company's Own Ships—
[5] And The Texas Company's Own Tank Cars—
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LUBRICATION PROTECTION

THE maintenance of industrial plant lubrication at the necessary standards to insure maximum production with the minimum of expense for operation and upkeep requires the most careful protection of lubricants and systems of lubrication.

It is safe to say that any lubricant can only be as effective as its purity. In other words, overheating or contamination with dust, dirt, metallic particles, and water will not only reduce lubricating ability, but will be a direct hazard due to the possibilities of wear, burned out bearings and machine breakdowns occurring.

This matter of lubrication protection is broad in the extreme. It involves not only actual cleansing of lubricating oils in service, but protection of lubricators, systems and wearing elements against the entry of contaminating foreign matter, or the development of excessive heat.

Provided that lubricants are of the requisite degree of purity and refined and selected to meet the operating conditions, the ultimate extent to which maximum lubricating results will be obtained will depend upon cleanliness and the prevention of contamination throughout the period of usage. This means keeping oil and air as free as possible from dust and abrasive foreign matter.

Oil Filtration and Purification

Cleansing of lubricants by means of filtration or centrifugal purification is accepted as one of the outstanding factors in the maintenance of effective lubrication. Lubricating oils today, as refined and marketed by the reputable oil companies, are clean and free from foreign matter.

Refinery, pump house, storage, packing, and transportation methods have been worked out with purity as the outstanding objective. In consequence, turbine oils, steam or Diesel engine bearing lubricants, transformer oils, or those products so extensively known to the railroad man as car oils are certainly of a wide variety in regard to physical properties, appearance and requirements. Yet they are all of proportional purity according to these requirements, when delivered to the ultimate consumer.

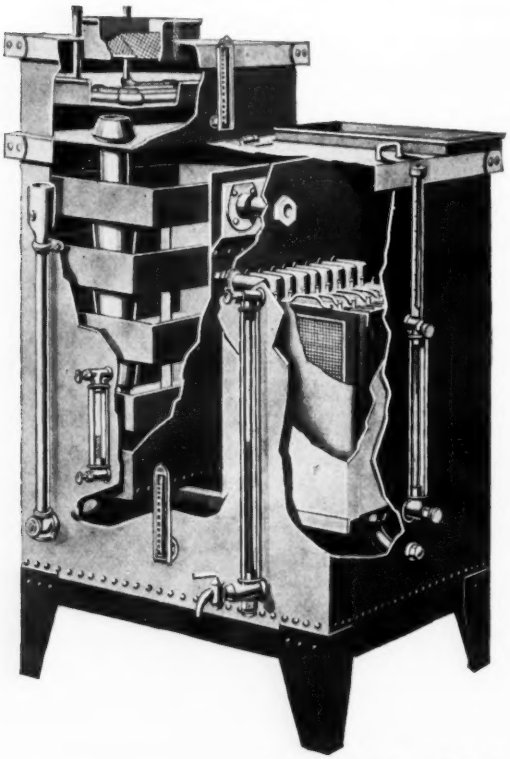
In service, they must be kept up to approximately their individual standards of purity, otherwise their lubricating ability will be reduced to a certain extent. It has been claimed that oils do not wear out in service; that they only become contaminated. This would appear to be borne out by the fact that a turbine oil, for example, can be run continuously for months with but a relatively small amount of make-up necessary to compensate for loss by evaporation or in the process of cleansing.

On the other hand, continued service and contamination can rightly be expected to reduce the lubricating ability of any oil. Therefore, the above theory should normally not be taken too literally.

TYPES OF SYSTEMS

Lubricating oils can be reconditioned or cleansed by one of three distinct methods, viz.:

By precipitation and filtration
By centrifugal separation and
By mechanical coagulation of the impurities with suitable chemicals.



Courtesy of S. F. Bowser & Co., Inc.

Fig. 1—Cut-away view of a modern lubricating oil filter which combines precipitation with filtration in the removal of foreign matter, water and sludge. Precipitation trays are shown on the left, the filters being located in the right-hand compartment. Oil passes first over the former and then through the latter. A heating coil is located above the precipitation compartment.

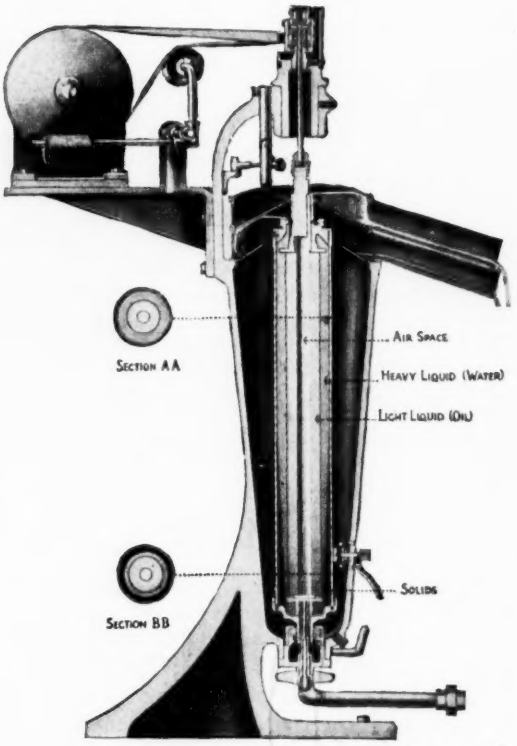
PRECIPITATION AND FILTRATION

Modern practice in oil reconditioning usually provides for application of the principles of both precipitation and filtration in the same equipment.

Precipitation alone is an extremely lengthy operation, though dependent of course upon the viscosity of the oil and the amount of foreign matter contained. Normally, too much time would be necessary for proper clarification of an oil. The rate of precipitation can be expedited by heating the oil to a certain extent to reduce its body, or, by addition of certain substances which differ sufficiently in specific gravity, to increase the rate of settlement of the contained impurities. Over the period of precipitation the oil should of course be as quiet as possible, for agitation to any extent would obviously interfere with settlement of material heavier than the former.

In consequence, precipitation is generally resorted to only for partial clarification or removal of larger and relatively heavier particles of foreign matter. Final treatment is carried out by filtration or screening the oil through porous material with openings fine enough to retain the majority of the remaining impurities. Wire cloth or finely woven canvas may be used for this purpose. The extent to which ultimate purification will be attained will depend upon the length of time the oil is treated and the fineness, weave or density of the filter.

It is not usually necessary to attempt to bring an oil completely back to its original state of purity. Too much time and too intricate equipment would be involved. The extent of reconditioning should be based upon the grade of oil under treatment and the service it must do. Obviously steam turbine lubricants would require more careful treatment than car oils; the requirements imposed are, in general, more severe.



Courtesy of The Sharples Specialty Co.

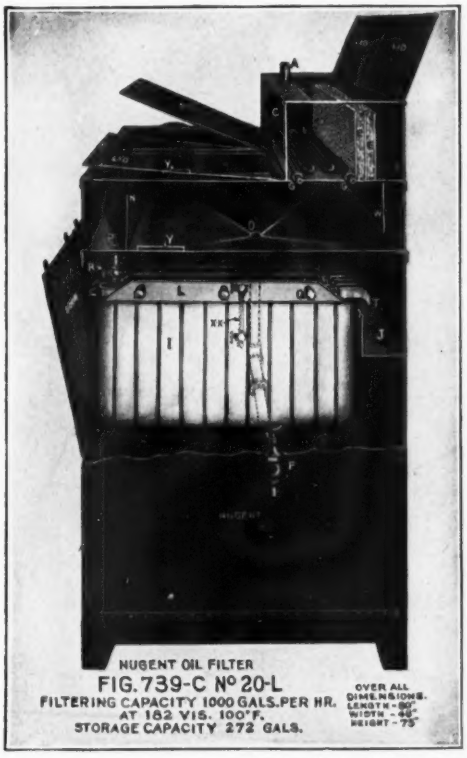
Fig. 2—Details of a centrifugal separator showing features of construction. Note the cylindrical bowl wherein separation takes place as indicated.

FILTER CONSTRUCTION

The modern industrial or power plant oil filter will in general provide for combined precipitation and filtration. The oil as received from the lubricating system, etc., is run to a strainer box to take out any larger, heavier particles of foreign matter, or, to a heating tray, especially if it is a heavier, more viscous product, in order to promote subsequent precipitation and separation of as much water and sludge as possible.

After suitable heating the oil is passed to the precipitation compartment over one or more precipitation trays at comparatively low velocity. Foreign matter naturally settles to the bottom here; water is led off through by-passes or slots to prevent it being carried through to the filters.

After the oil has been freed of heavier foreign matter by precipitation it is passed to the filter compartment. In this latter in rigid arrangement are the filtering units. Filter bags or metallic frames covered with finely woven filter cloth are used for this purpose. Dirt and foreign matter accumulations on filter cloth will form an additional filtering media to a certain extent.



Courtesy of Wm. W. Nugent & Co.

Fig. 3—View of another type of oil filter. Here contaminated lubricating oil enters at A,—flows over steam coil G,—through filtering material EE,—via holes M,—to back of baffle plate W,—over weir N,—and thence via outlets P,—to filter bags I.

Filter material should be non-corrosive, as resistant to abrasive wear as possible, inexpensive, easy to install, non-soluble in oil, of such a weave as to give a uniform rate of filtration over the entire surface, and it should have no tendency to give off shreds or disintegrate in any way to perhaps contaminate the reconditioned oil.

Courtesy of The Delaval Separator Co.

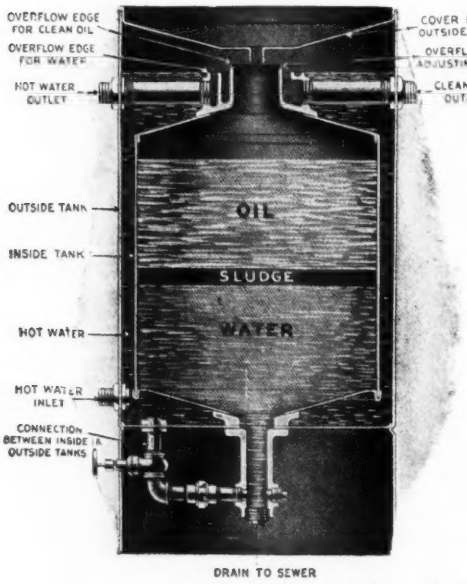
Fig. 4—Cross-section of an electric driven centrifugal separator showing arrangement and distinctive shape of the bowl, and the essential fittings attached.

CENTRIFUGAL PURIFICATION

The principles of centrifugal force are also applied to oil purification. Separation of substances or fluids of different specific gravity can be effectively brought about by centrifugal force, in a comparatively short period of time, due to the intensity of the force involved. As in the case of precipitation, moderate heating is an adjunct to effective separation by centrifugal force, due to the resultant reduction in viscosity of the oil under treatment. The extent of heating necessary would of course depend upon the viscosity of the oil, and to a certain degree upon the amount of contamination. Obviously a light turbine oil would not require as much heating as a relatively heavy Diesel engine oil.

SEPARATOR CONSTRUCTION

The typical centrifugal separator consists of a rotating bowl or cylinder contained within a suitable frame or housing. Oil to be treated is delivered to the top or lower part of the bowl according to the design. When the latter is



Courtesy of De La Vergne Machine Co.

Fig. 5.—Sectional view of an oil reclaimer especially adapted to oil engine service. In operation the used oil is subjected to a brief but violent agitation with a solution of hot water and a special coagulent. The effect brought about is claimed to be purely mechanical, being based on the scientific principle of the relative surface tensions of oil and water.

rotated metallic particles, dirt, sludge, water and oil are separated according to their relative specific gravities, solid matter being thrown to the sides or walls of the bowl. The water and oil are carried upward to be caught in suitable covers which are fitted with spouts for discharge to drain or clean oil tank respectively.

METHODS OF RECONDITIONING

Oil reconditioning is accomplished

(a) By periodic treatment of the entire volume of oil involved, commonly known as batch purification.

(b) By continuous treatment of this oil, or

(c) By continuous treatment of only the dirtiest oil from the bottom of the return reservoir or oil sump.

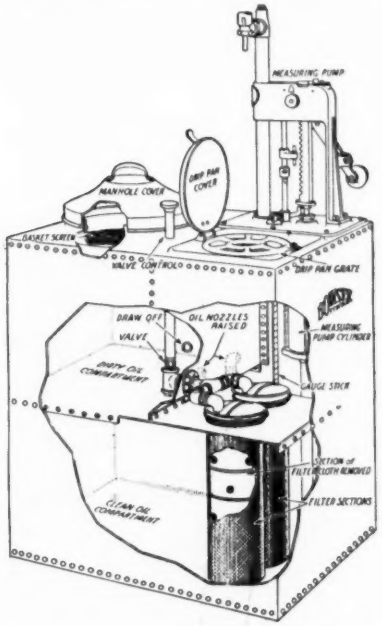
The method to use will depend upon the volume of oil involved, the degree of contamination of the oil and the class of service or type of equipment being lubricated. Any one of the above methods is applicable to either the filter or centrifugal device.

Batch Purification

Batch purification as its name implies is carried out intermittently, by draining the lubricating system completely of used oil, and filling it meanwhile with fresh oil from storage. This used oil is then run through the reconditioning equipment at hand, at a rate commensurate with the limitations of the latter.

A steam-heated settling tank will be an adjunct in promoting precipitation and removal of larger, heavier particles of foreign matter prior to transfer of the oil to the main filter or purifier. Batch treatment is not always practicable due to the fact that it entails a shutdown of equipment for draining and charging with fresh oil. Furthermore it often requires considerable storage facilities, and oil is frequently not changed until it becomes heavily laden with impurities.

Treating used, contaminated lubricating oils by the batch method is of course advantageous in that the requisite amount of time can usually be allowed for effective precipitation. On the



Courtesy of S. F. Bowser & Co., Inc.

Fig. 6—An oil filter adaptable to reconditioning of smaller batches of lubricating oils, etc. Note construction and location of the filters, and the comparative size of clean and dirty oil compartments.

other hand it may involve the installation of considerable storage equipment and the storing of frequently more oil for replacement than may be economical or desirable. Under such conditions continuous treatment or reconditioning of the oil may be employed. With this method reconditioning equipment is arranged in series with the lubricating system, the oil passing

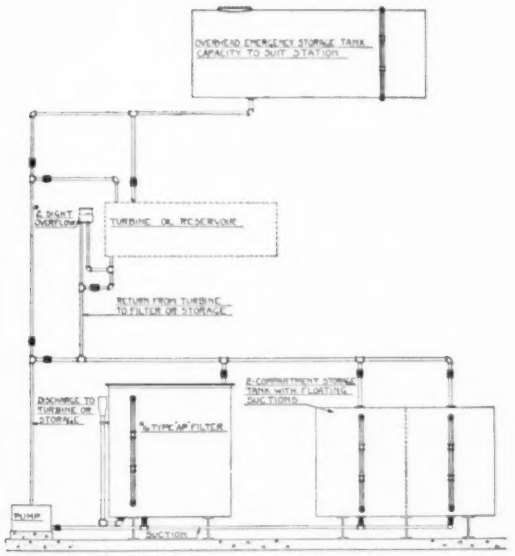
through the former after each circulation through the latter.

Continuous Treatment

Continuous treatment is a most effective method of insuring that the oil in service will be maintained at as nearly its original state of purity as possible. There will, in consequence, be but little chance of foreign matter finding its way to the bearings or other wearing elements. The length of time required for effective reconditioning, however, imposes more or less of a limitation upon the use of this method. As a rule it will be chiefly applicable to systems where a comparatively small volume of oil is being circulated. Where gallonage is high the expense for equipment and the amount of this latter required is extensive, and such complete reclamation of the oil will not be justified.

Continuous By-Pass Treatment

Under such conditions it is accepted practice especially in power plant service to use the continuous by-pass method. This constitutes the continuous withdrawal of a certain amount of oil from the lubricating system. The dirtiest oil should of course be removed in such a

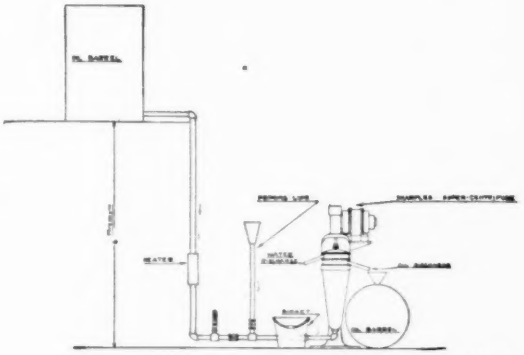


Courtesy of S. F. Bowser & Co., Inc.

Fig. 7—Layout of a turbine oil purification system using continuous by-pass and batch principles in combination.

system. To best effect this the by-pass is located at the lower part of the sump tank.

General practice in figuring the amount of oil to remove, is to take into account the extent to which water may gain entry through leakage or condensation, the amount of oil in the lubricating system, the viscosity and degree of refinement of the original oil, and the probability of foreign matter gaining entry. Normally if from ten to twenty percent is by-passed continuously for reconditioning, the bulk of the oil in the system will be maintained in a sufficient state of purity to insure effective lubrication.



Courtesy of The Sharples Specialty Co.

Fig. 8—An installation for reclaiming small batches of lubricating oil, by centrifugal purification. Note relative location of respective parts, and the necessary pipe connections.

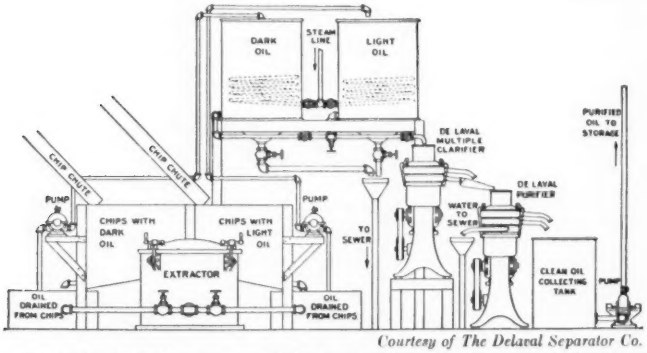
Filtration, precipitation plus filtration, or centrifugal treatment will all effectively recondition the by-passed oil in a system where the continuous by-pass method is employed, the resultant lubricant being returned to the system so free from water, sludge, emulsions and foreign matter as to frequently clarify the oil in the main reservoir to a marked degree.

In the operation of such a system it is of course important that the reconditioning equipment shall not be overloaded. Experience has indicated that a capacity sufficient to purify the entire volume of oil in the system in approximately four hours will be adequate to maintain the oil in service at the proper degree of purity, without any necessity for forcing or the accumulation of an excessive volume of impurities in the filter, or purifier bowls. This would of course entail frequent cleaning. When a turbine or engine for example is to be shut down for repairs it will also be advisable to run all the oil in the bearing lubricating system through the reconditioning equipment, and clean the oil sump or reservoir of any sludge or dirt. This will insure a fresh start on clean oil and will materially reduce the subsequent duty of the filter or purifier.

RECONDITIONING OF TURBINE OILS

In order to insure that a turbine oil will continue to function effectively and meet any detrimental conditions of operation, it must be maintained in a suitable state of purity. This does not necessarily mean that the oil

requires reconditioning until its original characteristics are brought back. In general, operating and installation conditions will not permit of this. Experiments have proven that, unless the proportions of water, sludge and emulsified matter present are considerable, an oil will normally possess sufficient lubricating and cooling ability to function perfectly satisfactorily—in other words, bearing temperatures will remain below the generally accepted safe limit of 160° Fahr. Yet the oil in circulation at the time might contain a certain amount of the aforesaid recognized impurities, as well as considerable organic acidity.



Courtesy of The Delaval Separator Co.

Fig. 9—In the machine shop reconditioning of cutting oils and removal of chips is also an important matter. The details of a system for this purpose using centrifugal means for clarification and purification of used oil are shown above.

Each method of reconditioning as heretofore mentioned has its respective place, inasmuch as each is particularly capable of removing certain varieties of foreign matter.

The efficiency which will be attained from filtration will, of course, depend upon the type of material through which the oil is to be filtered and the rate at which it is passed. As has been said above, it is not absolutely essential to remove every trace of impurity from the turbine oil. In fact, the oil in the lubricating system always contains a certain amount of foreign matter, with the exception of perhaps the first few minutes after new oil has been put into service. As a result, it is safe to say that the extent to which an oil must be cleansed or purified should be the governing factor as to the time of precipitation and the density of the filtering medium, or, if both methods are used in combination, the relative effectiveness of each as compared with the volume of oil to be treated and the time available.

While water can often be effectively added to a turbine oil which is to be purified by means of centrifugal purification, it should not be understood that this also applies to the use of an oil filter. In other words, wet filtration, as it used to be known, or the idea of passing dirty oil through water, is now seldom used. The impurities are not removed to any extent and the oil particles will tend to absorb water, which will be difficult to remove later on.

One of the most effective, though expensive ways of bringing about the proper reconditioning of turbine oils in the least possible time, is to use a centrifugal purifier in series with an oil filter. On the other hand, many concerns will not care to assume the additional expense entailed in the installation of both of these devices, hence they use whichever they may have available to the best of its ability.

Whatever means of reconditioning is to be adopted, it is well to give consideration to the matter of heating the oil. As a general rule, in order to facilitate the separation of impurities by reducing the viscosity of the oil, provision is usually made in the modern oil reclaimer, whatever its type, for the application of a certain amount of heat. For example, in connection with the operation of the centrifugal purifier with the average turbine oil, it will be found that heating will oftentimes aid in the separation of the foreign matter. This of course, will also depend to a certain extent upon the specific gravity of the medium involved.

On the other hand it must be borne in mind that the application of an excessive amount of heat will tend to bring about the formation of organic acids and additional oxidation. Also, excessive heat may cause the solubility of sludges which at lower temperatures would be insoluble, and in consequence thrown down. In other words, while heat may facilitate the removal of some varieties of foreign matter to a certain extent, it will also lead to the subsequent formation of others, due to the purified oil coming back into service in an acidic state.

In regard to organic acidity, it is interesting to note that of the several impurities which will usually be found in a turbine oil, it is the only one which cannot be satisfactorily removed by any of the standard forms of oil reclaimers. As yet, however, the extent to which organic acidity is directly detrimental in itself, is a point of discussion. In the opinion of authorities, even though there may be no practical means of bringing about its removal from an oil, there is a possibility that addition of water to a turbine oil, prior to centrifugal purification, will by virtue of the emulsions and sludges formed, tend to automatically reduce the amount of organic acidity. As a result, the oil which is subsequently put into the system again will be capable of going that much further, before it is once more oxidized, and sufficient organic acidity developed to bring

about a dangerous amount of emulsified matter and sludge.

Of course, wherever water is to be added to a turbine oil, this should be done after the charge to be purified has been drawn off or by-passed from this system. Under no condition should this be done while the oil is in circulation, due to the fact that the excess of impurities which would probably be thrown down would form a sufficient amount of additional sludge to congest the system to a dangerous extent.

OIL ENGINE SERVICE

Quite as important as the proper selection of lubricants for the oil engine is the matter of their purification during operation. Especially is this true where the engine is built with an enclosed crankcase, pressure lubrication being employed on the various bearings. Sediment will accumulate, and water of condensation is always a possibility; also leakage from the cooling system may develop to further contaminate the oil.

Emulsification and sludging will be the natural sequences if oils so contaminated are continued in service, clogged oil ways and bearing troubles being the culmination. The presence of iron oxides, such as rust, cause an increase in the rate at which all this may occur; especially will they hamper the separation of water from the oil. The oil in service must therefore be kept clean for it must not only lubricate effectively in order to reduce wear, but also it must be capable of protecting the wearing surfaces against rust or corrosion when the engine is shut down.

Carbon, which is another prevalent contaminating agent, is also a sludge creator, tending, in addition, to impair proper lubrication even when held in free suspension in the oil. Furthermore, this suspension of minute particles of carbon is claimed to render the problem of purification considerably more complex than it normally is in steam power plant service. In general such carbon will not settle out readily from the oil, rendering simple gravity separation a difficult matter. Filtration, centrifugal action, or agitation in presence of a coagulent capable of throwing down the carbon, however, are all effective methods of purification.

In addition these systems serve to remove water and other contaminating foreign matter. It must be borne in mind, however, that a certain amount of loss will accrue which must be taken care of by the periodic addition of a suitable amount of new or purified make-up oil.

Impure air in plants where dusty materials or products are being handled is also the frequent source of foreign matter, which as it usually consists of siliceous particles, has a decided scoring or abrasive ability. Of course, the oil purifier will remove such matter, but it is better to remove it at the source by using some filtering medium at the intake.

The centrifugal separator is also adaptable to the removal of grit, dirt or sediment from Diesel engine fuel oils. In this way abnormal abrasion of nozzles, fuel valves, cylinder surfaces and even bearings can be prevented. For abrasive dirt in the fuel will most surely impair cylinder lubrication, frequently even reaching the bearings, and bringing about a general condition of wear which can and should be prevented by removing such foreign matter from the oil before it is fired.

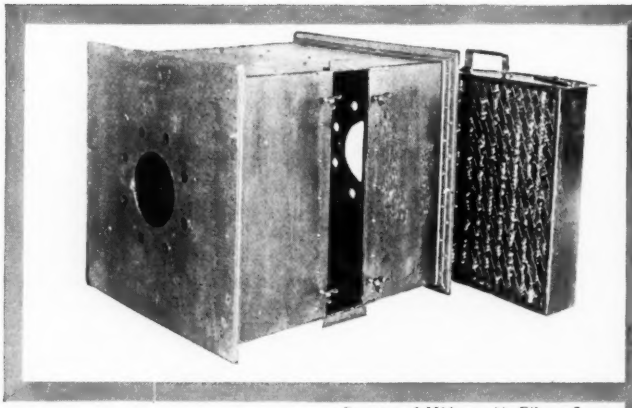
Filtering and Cleaning of Air

In the attainment of effective lubrication the prevention of entry of foreign matter sufficiently fine to be carried by the air is of decided importance. All industrial machinery is subject to the detriments of dirty air. Certain equipment such as the air compressor, oil engine or gasoline engine in addition will actually have to take this air into their working elements in the performance of their intended functions. Others including much of the actual process or fabricating machinery of industry will operate in dust laden atmosphere to the almost positive detriment of such bearings, gears or chains, as may be exposed or so constructed that dirty air may have access thereto.

It is of course impossible to absolutely eliminate dirty air conditions; screening of windows and doors will prevent larger particles of dust from entering, but finer dust will get by to be an ever prevalent detriment to lubrication unless steps are taken to remove it from the air which is to actually pass through the equipment or come in contact with its wearing elements to any extent.

Such air should, therefore, be filtered whereever necessary, the volume so treated per hour, let us say, depending upon the size of the filter installation and the requirements of the plant. Normally it will not be necessary to filter all the air which is circulated through any particular room or building. In general only such air will require filtering as is to be taken into air compressors, automobile engines, oil engines, etc., or is to come into direct contact with electric generating equipment for example.

On the other hand, any industrial process

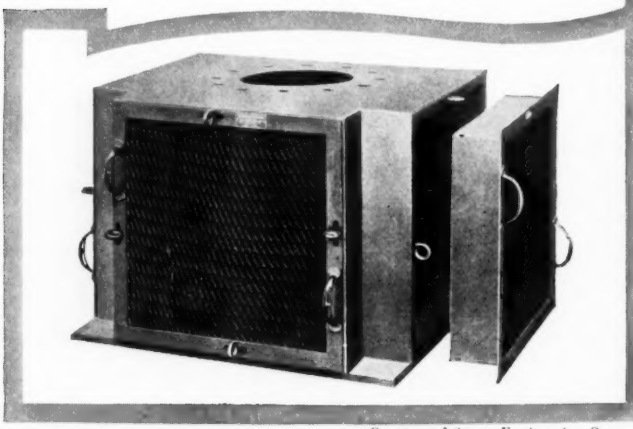


Courtesy of Midwest Air Filters, Inc.

Fig. 1—Details of a filter for use in the air intake of a compressor. Small metallic cylinders compose the filtering media.

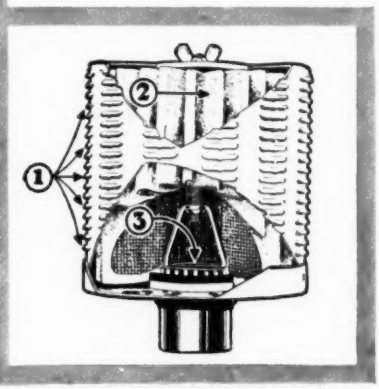
Courtesy of Reed Air Filter Co., Inc.

Fig. 4—Constructional details of a high pressure air filter. Split wire is used in this device.



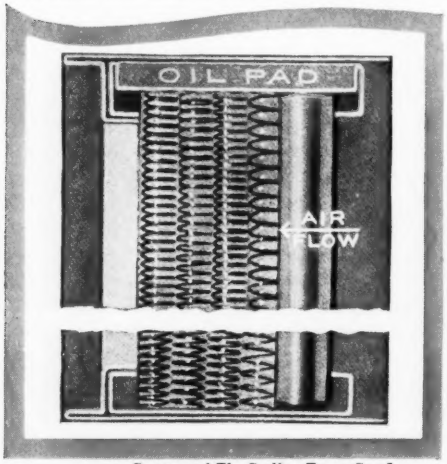
Courtesy of Spray Engineering Co

Fig. 2—For air compressor and oil engine service the box type of filter as shown above is advantageous. Each cell is held in place by quarter-turn locking screws. Expanded metal sheets form the basic filtering media.



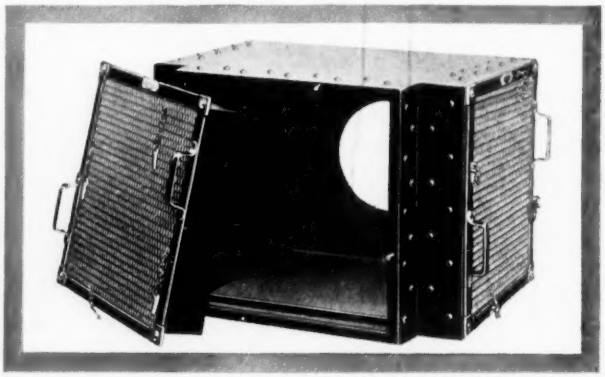
Courtesy of Staynew Filter Corp.

Fig. 5—Cut-away view of a circular filter using felt fabric for filtering purposes. Air enters at (1), through openings in the circular shell, passes through the filter vanes (2), where dust is removed, and passes out via (3).



Courtesy of The Cooling Tower Co., Inc.

Fig. 3—Section through an air filter in which wire coils compose the filtering media; these are graduated in size from intake to outlet to increase the density. Note the oil pad above the coils, and the reservoir in the base.



Courtesy of Reed Air Filter Co., Inc.

Fig. 6—A box type of filter with one cell removed, showing comparative size of intake. Split wire suitably coated with a dust-absorbing fluid is used in these filter cells

requiring cleanliness can be protected by the modern air filter. In other words, the lubrication of important working elements can be rendered more effective by guarding against the possible contamination of their lubricants with abrasive dust or other foreign matter. Presence of solid foreign matter in any lubricating film will tend to impair its ability to serve

Courtesy of The Cooling Tower Co., Inc.

Fig. 7—Cleaning a set of filter cells to remove dust and used absorbing fluid. Note cleaning tank, drain rack and the ease with which the cell can be handled.

as a friction reducer. This will be largely due to lack of homogeneity in the film and the possible occurrence of actual solid contact between shafting, bearings and such solid foreign matter as may have worked in between them. This explains, in part, why bearing elements frequently become scored or abraided, oftentimes even when lubrication is apparently effective.

PRINCIPLE OF AIR FILTRATION

In view of the evident relation which exists between lubrication and cleanliness, it is decidedly important to know more about this matter of air cleaning or filtering, and the systems devised for its accomplishment.

The modern air filter is based on the principle of the human nostril, in that by suitable arrangement of the filtering media and certain baffles, the passage of dust is arrested even though there is free access for the air. As the filter becomes clogged or its pores or interstices filled with foreign matter, air will pass through with more or less difficulty. It is for this reason that periodic cleaning is necessary.

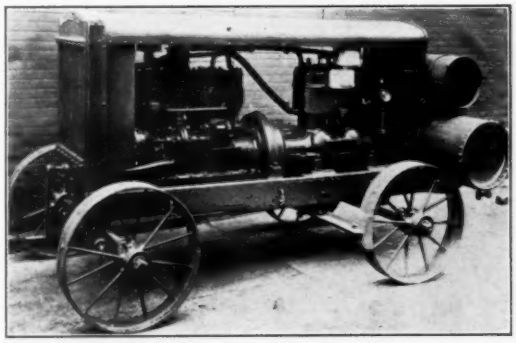
USUAL CONSTRUCTION

The air filter for general industrial or power plant service will as a rule involve a suitable container, cell or box in which is contained fine wire such as steel wool, metallic particles, expanded metal sheets, small metallic cylinders or felt vanes, etc.

Where metallic filtering material is used it is regarded as advisable to grade it in coarseness from intake to outlet, the finest media being located adjacent to the clean air outlet. To further aid in the separation of dust from the air certain authorities deem it advisable to provide for repeated change in direction of the latter. In one well-known filter involving split wire for filtration, the direction of the air is claimed to be changed from eleven to eighteen times. Each change of course tends to throw a certain amount of dust into more intimate contact with the filtering media, to be retained and prevented from further passage through the filter. When metallic filtering material is involved, it will be advantageous and expedient to have it coated with a light film of an adhesive fluid in order to promote retention of solid foreign matter. Light lubricating oil having a viscosity of from 200 to 300 seconds Saybolt at 100° F. has proven to be suitable for this purpose.

CLEANING OF FILTERS

The continuous filtration of dust-laden air will of course result in accumulations of foreign matter within the filtering media. The extent to which these will build up will naturally depend upon the normal dust-content of the raw air. In any event more or less resistance will be presented to restrict free passage of air, with the result that the amount of air delivered



Courtesy of Staynew Filter Corp.

Fig. 8—A portable air compressor equipped with a circular type of air filter, to clean the air prior to compression. On many construction jobs where such a compressor is used, air will have a high dust content.

(which is in reality a measure of the efficiency of the filter) will be reduced.

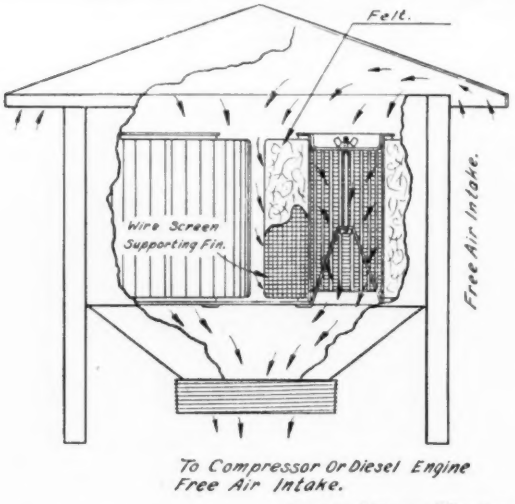
Consequently it will be necessary to clean the filter cells at regular intervals. The average frequency of cleaning in most industrial plants will range from one to three months. Cleaning of metallic filters can be effectively carried out by use of a hot soda solution in a vat or

tank of suitable size (See Fig. 7). Soda effectively "cuts" or dissolves dust, dirt, grease and oil, hence by dipping and sluicing the cells in such a solution the filtering media can be brought back to condition, the pores cleaned and the entire device rendered once again fit for developing maximum efficiency. Metallic filters which manufacturers recommend coating with oil or any other dust-absorbing fluid should be re-dipped in such a medium after cleaning, being allowed to drain of any excess oil, etc., before replacement in the bank.

Felt vane filters can be cleaned in place, by blowing air through, from the inside of the inserts. This effectively removes dust accumulations from the exterior surfaces.

AIR COMPRESSOR SERVICE

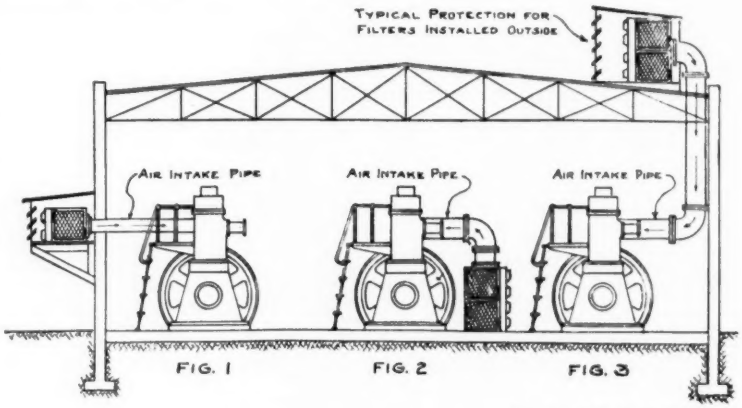
The fact that efficient air compressor operation is decidedly dependent upon clean air and effective lubrication renders discussion of such equipment of vital importance. Air compressor explosions or failures in after-coolers or any of the connecting lines are chiefly due to accumulation of deposits which restrict the free passage of the air and lead to abnormal temperatures by reason of frictional resistance.



Courtesy of Staynew Filter Corp.

Fig. 9—Details of a compressor or Diesel engine air filter installation showing construction of filter inserts, path of air and manner of intake.

Deposits of this nature may result from continued usage of lubricating oils of high carbon content. They are more liable, however, to be caused by entry of dust along with the air which is to be compressed. Were such foreign matter able to pass through with the air the result would not be as serious. There will be tendency, however, for it to remain in the system, especially where lubricating oil is used to any excess, to result in gummy deposits around valves, in cylinder clearances in inter-coolers, after-coolers, and air lines.



Courtesy of Reed Air Filter Co.

Fig. 10—Three methods in which an air filter can be installed on an oil engine, according to location of intake.

It is safe to say that all air for compressor service will carry an appreciable amount of fine abrasive dust. The nature of this latter, will, of course, depend upon the elevation and location of the installation. In flat, suburban or farming districts where road traffic may be fairly heavy, winds prevalent, etc., the resultant dust which will be bound to occur will probably be of an earthly or siliceous nature. In contrast, the dust content of the average air in mining or smelting localities, or industrial centers will include ash, coal dust or more or less mineral matter, but of course all in very finely pulverized condition.

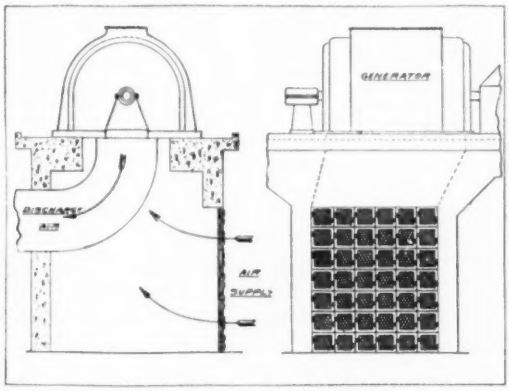
In consequence steps should be taken wherever possible to protect air compressor equipment and insure effective lubrication by properly filtering the air prior to its being drawn into the system. This means the installation of adequate filtering equipment at the intake.

Carbon Deposits

Inasmuch as the lubricating oil may cause, or lead to deposits of more or less intensity, depending upon its carbon content and the operating conditions involved, more discussion in this regard will be of interest.

Deposits of carbon plus dirt on the valves or in the discharge lines of an air compressor are to a certain extent, caused by decomposition of the oil. It is an accepted fact that mineral lubricating oils, regardless of their base or nature, will decompose to volatile products

and carbon when subjected to hot air under pressure. The extent of this decomposition of course depends on the length of time the oil is exposed to such heat. Naturally, also it will follow that the oil which remains in the compressor cylinder or on the discharge valves the longest, will form the greatest amount of carbon.



Courtesy of Spray Engineering Co.

Fig. 11—An electric generator air filter installation, showing path followed by air supply, and the relative location and number of filter cells involved.

On the other hand, analysis of numerous so-called carbon deposits has proven them to consist more of dirt than of carbon, the whole being held together by gummy matter from decomposed oil. For this reason a compressor oil having a wide range of distillation, high end point, or too great a viscosity is objectionable, inasmuch as, instead of vaporizing cleanly, it breaks down as has been mentioned above, becoming sticky and collecting dirt brought in by the air. The slower the breaking down process, or the greater the volume of oil involved, the more carbon will ultimately be formed.

Pale filtered oils, properly refined, are very free from both direct carbonization and the collection of carbonaceous matter. Furthermore, any such direct carbon that may be formed through excessive use, is of a light, fluffy nature. Carbon deposits formed from improperly refined or unsuitable oils, on the other hand, are often of a hard flinty nature. Any oil however, will accumulate dust if the air is dirty.

Air Compressor Explosions

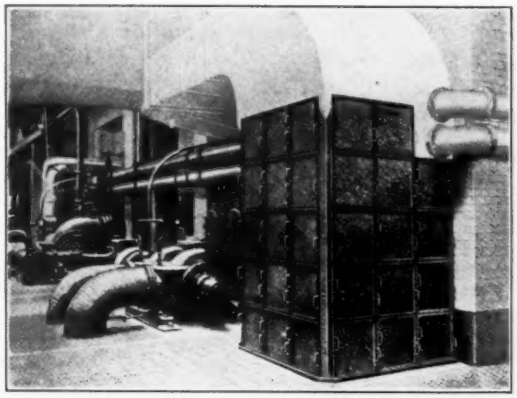
This matter of explosions is of the utmost importance to all who have to deal with air compressor operation and lubrication. Explosions occur due to accumulations of carbonaceous matter becoming heated to the point of combustion when abnormally high temperatures are involved due to leaky valves, either causing the metal to burn through and blow out, or bringing about the ignition of gaseous (oil and air) vapors which may have resulted from oil collections in pockets, etc. Localized vaporous accumulations of this nature will practically always become sufficiently condensed in time to form a "critical" or combustible mixture of air and oil vapor, requiring only intense heat or a spark from incandescent carbon to bring about an explosion.

Two distinct factors therefore, require consideration, i. e. :

1. The extent to which carbon deposits or accumulations of dust, dirt and oil, etc., are involved, and
2. The generation of excess heat, due either to air leaks in the discharge or final stage of compression, especially at the time of "unloading", or increased velocity of flow through the lines.

Carbon deposits or "carbonaceous" matter in general, does not strictly denote pure carbon, or in other words, carbonized oil. In fact, the proportion of fixed carbon to volatile matter in many cases will be relatively low.

Silica, iron, copper and zinc have all been found present, proving that a considerable portion of any such deposits can therefore be regarded as consisting of substances which are either drawn in by the original charge of air, or abraded from the metallic parts of the system, the lubricating oil as a source of being but partially responsible.



Courtesy of Midwest Air Filters, Inc.

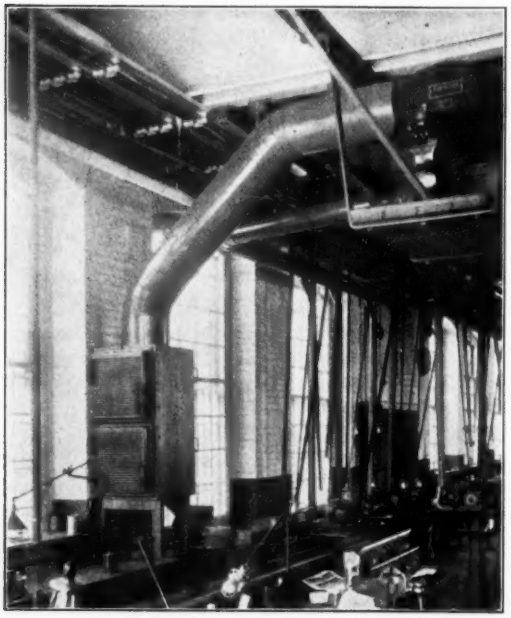
Fig. 12—The position which a bank of air filter cells would occupy in a turbo-generator plant is shown above. Clean air affords marked protection for lubrication and the high-speed bearings which are involved in such a plant.

OIL ENGINES

Air which must be used in connection with oil engine operation for scavenging and combustion should be as clean and free from abrasive foreign matter as possible. Of course this will be most important in the full Diesel engine where air is not only mixed with the fuel prior to combustion, but is also used to

bring this about. Yet in the semi-diesel, it is likewise of importance, for dirty air will preclude efficient operation by increasing deposits and perhaps causing scored cylinders, etc.

More detailed discussion of the reasons for this will be of interest. While all air will



Courtesy of Midwest Air Filters, Inc.

Fig. 13—View of an air filter installation in a grinding shop. Note air duct to overhead blower.

contain a certain amount of minute abrasive, foreign matter, of course in certain localities and in certain industries where oil engines are employed this will be far more in evidence than in others. The marine Diesel engine for example, will usually function on comparatively dust-free air, and therefore might not require any air filtration, whereas, a stationary engine operating in a stone working plant, would be a decidedly fit candidate for attention in this regard. Essentially, therefore, the oil engine operator will be confronted with the problem of determining the dust content of the air in his engine room.

In the counteraction and partial elimination of deposits and so-called carbonaceous matter in the cylinders, etc., of oil engines and oil engine air compressors, it is well to bear in mind that dust and other foreign matter carried in with the air is one of the chief promoters of these evils. In fact the amount of carbon developed in the normal operation of the average Diesel engine using medium gravity fuel and high grade lubricating oil, will usually be practically neglible.

So it is with the solid, non-combustible matter that we are more distinctly concerned, especially, too, if the fuel as well as the air contains such impurities or is so injected that incomplete combustion takes place. Under such conditions a cementing medium would be developed or left as part of the fuel residue which would soon absorb any dust and dirt carried in with the air, and collect on the piston heads, the walls of the combustion chamber, and even around the rings. The use of an excess of lubricating oil would increase the percentage of potential gummy residue, and not only aid in the formation of deposits but also tend to seal the rings.

It is conceivable that dust and dirt might have a certain catalytic action in this regard, for as is true in the automobile engine, cylinder deposits are noticeably increased when dirty air is used. In other words the dirt and dust carried in by the air prevents the burning out of true carbonaceous residues during operation.

ELECTRICAL EQUIPMENT

To insure effective lubrication of the bearings of electric generators and motors, and to prevent injury to the windings, it is essential to protect them at all times from entry of abrasive foreign matter. In many such installations there will be possibility of the occurrence of windage, that is, the passage of air through the bearings. This will of course depend upon bearing construction and whether provisions are installed for counteraction.

In certain of such equipment baffles or dust guards are employed. These latter will effectively reduce windage, and serve to prevent oil being carried from certain types of bearings. But where there is any draft, and the dust content of the air is comparatively high, there will still be considerable probability of abrasive matter penetrating to bearings, or the windings of open motors, etc. to ultimately impair operation.

For this reason it will be advisable to give consideration to air conditions, and the potential benefits to be derived from better lubrication by proper filtering of the air.

Babbitted bearings will be the most liable to suffer from abrasive impurities in the air. Ball and roller bearings can as a rule be more tightly sealed by virtue of the nature of their construction. This is important to remember where pressure lubricated generator and turbine bearings are involved. The installation of air filters for such service can be carried out in much the same manner as for the oil engine. Figs. No. 11 and No. 12 show typical installations in connection with electric generators.

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